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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 5 September, 1926 Number 9

Program
Fall Meeting
American Welding Society
Buffalo, N. Y.

November 16, 17, 18 and 19, 1926

Headquarters

Technical sessions, exhibitions, demonstrations—*Broadway Auditorium*

International Welding Exposition

One of the largest Welding Expositions will be held in connection with this fall meeting showing new developments in welding apparatus and supplies. A unique feature of this Exposition will be an exhibit of a large variety of welded products. The Exposition will open on Tuesday afternoon, November 16, the day preceding the Annual Fall Meeting of the Society, and will close on Friday, November 19 at 5 p. m. It will also be open on Tuesday and Wednesday evenings.

Inspection Trip and Buffet Supper

On Friday afternoon, November 19, 1926, an inspection trip has been arranged to Niagara Falls. Members of the Society and their guests will view the Falls from the American side with a short inspection trip through the Niagara Falls Power House. This will be followed by a buffet supper on the Canadian side and then a special illumination of the Falls will be shown, returning to Buffalo late in the evening. The exact time and place for assembly of members and their guests will be announced at the Exposition Headquarters. Reservation per person for this trip and supper is $1.75.

Dinner Dance

A Dinner Dance will be held Thursday evening at the Hotel Statler. Special arrangements have been made as to entertainment features which will insure a good time for everyone who attends. In addition, arrangements have been made for an excellent dinner. Reservations should be made at once by applying to

Mr. Carl D. Miller, 510 Morgan Building, Buffalo. Price per plate, $6.

Attendance

Indications are that there will be several thousand people in attendance at the various technical sessions, inspection trips, committee meetings and exhibits, including representatives from all parts of the United States and Canada. Several exhibits of European manufacturers are also included.

Hotels

Special arrangements have been made with a number of hotels, some of which are listed below, with the minimum rates for single room with bath:

Hotel Broezel, $3; Buffalo, $2.50; Greystone, $2.50; Lafayette, $3; Lenox, $3; Stuyvesant, $2.50; Statler, $4; Touraine, $3.

Badges

Admission to exhibit hall to be by badges only; all members of the American Welding Society and exhibitors, including their authorized representatives, will be furnished with admission badge free of charge, other visitors will be charged 25c. for the admission badge, which includes copy of official program.

TECHNICAL PROGRAM

WEDNESDAY, NOVEMBER 17, 1926

Morning

10 a. m. to 12 m.

"Welding of Locomotive Parts," M. Gjersten, Master Welder, Northern Pacific Company.

"Organization of Welding on the Railroad," F. H. Williams, Assistant Test Engineer, Canadian National Railways.

Afternoon

2 p. m. to 4 p. m.

"Comparative Tests on Arc and Riveted Structural Members," A. M. Candy, General Engineering Department, Westinghouse Electric and Manufacturing Co.

"Tests on Welded Roof Truss," H. H. Moss, Linde Air Products Company.

THURSDAY, NOVEMBER 18, 1926

Morning

10 a. m. to 12 m.

"Welding Science in the Engineering Curriculum of Universities." Prof. G. J. Hoffman, Purdue University; Prof. B. L. Lucas, Mississippi Agriculture and Mechanical College; Prof. S. T. Hart, Syracuse University, Prof. deZafra, New York University; Prof. R. D. Rickley, Ohio State University; Prof. F. V. Larkin, Lehigh University.

Afternoon

1:30 p. m.

Welding Wire Specifications Committee. C. A. McCune, Chairman.

2:30 p. m.

Meeting of the American Bureau of Welding. The remarkable progress made by the welding research department of the American Welding Society (American Bureau of Welding) will be a source of satisfaction to the members of the American Welding Society and the welding fraternity.

Evening

7 p. m.

Dinner Dance. For details see page 3.

FRIDAY, NOVEMBER 19, 1926

Morning

9 a. m. to 10:30 a. m.

Short technical session on "*Welding in a Gaseous Atmosphere,*" including demonstrations, and exhibitions will be made by Mr. P. P. Alexander and Mr. R. A. Weinman of the General Electric Company.

10:30 a. m. to 12:30 p. m.

Meeting of the Board of Directors, American Welding Society.

Afternoon

1:45

Inspection trip.

For details see page 3.

YEAR BOOK

The first issue of the Year Book of the American Welding Society was printed as the August issue of the Journal. The last two pages of this Year Book contains a membership application blank for the convenience of prospective members. Additional copies of this Year Book will be sent to any member upon request to be used in the solicitation of new members.

As has been pointed out many times in the editorial columns of the Journal, the strength of the Society is in a measure dependent upon the number and character of members. New members can be best obtained through personal contact. Each member of the Society is therefore earnestly requested to secure at least one new member during the next few months.

FALL MEETING

The program of the Annual Fall Meeting of the Society, just preceding this editorial, shows that no effort has been spared to make the coming Fall Meeting of the Society an outstanding event of its history. The success or failure of any convention of this sort depends upon the backing of the membership through attendance.

Aside from the obvious advantages of attending, there are reasons which are sometimes overlooked but which are very important. Meetings of this sort provide an opportunity for association with others in the same field and discussion of problems which are of mutual interest. This results often in the obtaining of new ideas and suggestions and creates good fellowship. The Exhibitions will serve to keep our

members abreast of the latest developments in the applications of welding, new apparatus and supplies.

WELDING OF STRUCTURAL STEEL

It has been the fondest hope of some of our welding enthusiasts to extend the applications of welding to fabrication of large structures, such as buildings, bridges, etc. Two years ago, practically the entire technical session of the Fall Meeting of the Society in Cleveland was given over to papers to demonstrate the adequacy of the several welding processes for the fabrication of steel structures. Test data and details of existing welded structures were painstakingly collected by prominent members of the Society and published at that time. Since then, a number of additional important all-welded structures have come into existence. A large number of expensive tests have also been made on full size structural members, which will be reported on in later issues of the Journal.

The American Welding Society, through its research department (American Bureau of Welding), has had under way careful plans for inaugurating a comprehensive, scientific investigation in this field. The assistance of the American Institute of Steel Construction has been recently secured and a committee is now being organized under the chairmanship of J. H. Edwards, assistant chief engineer of the American Bridge Company. The personnel of this committee will, no doubt, be of interest to our membership and is given below:

J. H. Edwards, chairman; assistant chief engineer, American Bridge Co.

W. Spraragen, secretary; American Bureau of Welding.

L. Allen, manager, Carnegie Works, McClintic-Marshall Co.

G. A. Caldwell, Mississippi Valley Structural Steel Co.

A. M. Candy, Westinghouse Electric & Mfg. Co.

J. J. Crowe, Air Reduction Co.

C. S. Davis, consulting engineer.

E. A. Doyle, Linde Air Products Co.

E. H. Ewertz, general manager, Moore Plant, Bethlehem Shipbuilding Corporation.

F. M. Farmer, chief engineer, Electrical Testing Laboratories.

J. C. Lincoln, Lincoln Electric Co.

L. H. Miller, American Institute of Steel Construction.

J. W. Owens, Newport News S. B. & D. D. Co.

W. L. Warner, General Electric Co.

S. C. Weiskopf, consulting engineer.

A. Weymouth, chief engineer, Post & McCord.

H. A. Woofter, Swift Electric Welding Co.

Representation is also being solicited from two or three other societies. Some of the problems in this field pointed out by Mr. Edwards in a paper recently presented before the American Welding Society are:

a. Can standard structural steel be satisfactorily welded and what are its limitations? If this grade of material is not suitable, what is?

b. What effect will the welding process have on the parent or main material?

c. Standard methods of making welds by different processes should be determined. Values on some unit basis for the strength of welds of different types should be fixed.

d. Some reliable way of controlling the mechanical and personal element in the making of welds and in testing the completed work should be established.

SECTION ACTIVITIES

Cleveland:

The following officers for 1926-7 were elected: Chairman, Prof. Herbert M. Boylston, Case School of Applied Science; vice-chairman, R. B. Fehr, Una Welding & Bonding Co.; treasurer, G. B. Close, Ohio Chemical Co.; secretary, R. K. Randall, Cleveland School of Technology. Program committee—J. C. Lincoln, chairman; J. H. Thornton, H. G. Dyar and R. B. Fehr. Membership committee—O. J. Bornemann, chairman; A. F. Davis, K. Haas, R. J. Hurt, J. E. Wolcott, Jr.

Chicago:

A very interesting meeting was held on Sept. 17, at which H. A. Woofter, chief engineer of the Swift Electric Welder Company, presented a paper on Resistance Welding. The discussion following Mr. Woofter's address took up considerable time and was entered into by many of those present, indicating genuine interest in resistance welding. Mr. Woofter's paper was illustrated by lantern slides. After the discussion of Mr. Woofter's paper, E. J. Henke, presi-

dent of the American Electric Fusion Corporation, presented motion pictures showing the construction and operation of spot welding machines and seam welders, which also proved very interesting.

Pittsburgh:

The following speakers are scheduled to appear before the Pittsburgh Section: October, Robert E. Kinkead, Lincoln Electric Company; November, S. W. Mann, Electric Welder Controller Co.; December, E. Wanamaker, Chicago, Rock Island & Pacific Ry. Co.; January, R. K. Randall, Cleveland Y. M. C. A.; February, J. C. Lincoln, Lincoln Electric Company.

Northern New York Section:

This section will hold its first meeting of the 1926-1927 season at the Pittsfield Works of the General Electric Company, on Sept. 29. All those attending will assemble at the Auditorium, Building No. 16, at 2.30 p. m. for an inspection trip through various departments of the factory, where various welding operations are being used. After the inspection trip, dinner will be served in the Works restaurant, free of charge, to those attending the meeting. Promptly at 7.30 p. m., a technical session will be held in the Auditorium, Building No. 16, when H. W. Tobey, of the Laboratory, will read a paper on "Electric Resistance Welding." Mr. Tobey will explain the results of research work in resistance welding and give details of operation of certain special seam welding machines which he has developed. His paper will be illustrated by lantern slides, and there will be an exhibit of welded specimens.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be addressed to the number indicated in each case and mailed to Society headquarters.*

POSITIONS VACANT

V-34. Want to secure an acetylene welder who is proficient in the art of welding holes in defective cast iron castings. Position is a steady one.

SERVICES AVAILABLE

A-48. Welder desires position. Have had four years' experience in boiler and tank work. Can also weld cast iron and high pressure work.

A-49. Electric welder desires position. Have had all around experience, including several years with Lackawanna Railroad, and have also had arc, spot and gas welding experience with R. Hoe & Company and Siemund Wenzel Company.

Essentials in Fusion Welding*

S. W. MILLER†

There is no need of stressing the importance of fusion welding in boiler work, as its use is taken as a matter of course in both new construction and repairs and you are all familiar with its many applications.

There are, however, several things that I should like to emphasize, that are to my mind of more importance than sometimes thought.

One of these is the vital necessity of always doing first-class work. It may be true that a weld in a side sheet will stand the hydrostatic test and even perform well in service for quite a while, even if it is made poorly, or with an inferior quality of welding rod, or if too little of the sheet has been cut away to get back to sound metal. But there is no doubt that better workmanship, better rod and sound metal will result in longer and better service, and probably will save one or more engine failures.

Another thing is to design properly the joints for welding. For instance, a lap joint with a large lap in a fire-box sheet is not good, because the metal in the lap on the fire side cannot be kept cool enough to avoid overheating.

On the other hand, the shorter the lap the greater the bending stress on the joint when under tension. So there must be a point where, for any particular joint, the amount of lap is best, and this may not be the same for all joints.

One of the most important, yet often a difficult matter, is to design welds so the welder has the best chance to do good work. Of course there are some welds that must be made in places hard to get at, but some thought will generally find the best design from the welder's standpoint as well as from others.

The hardest case is when awkward position is combined with a bad location for a weld, that is, where a weld has to stand undue stresses. For instance, the lug on the lower end of a pedestal jaw that fits in the pedestal brace sometimes breaks off and a small forging may be made and welded on. After a short time it is very liable to break again. The proper design is to cut through the jaw and lower bar of the frame and weld in an entire new piece, placing the welds where they can be easily and well made and where they will not be heavily stressed.

Another matter is the materials to be used. It is often beyond the power of the shop to secure changes in material specifications, but it is entirely within their province to point out that certain materials are better for welding than others. Fortunately boiler and fire-box steels are easily welded. It is at times necessary to

*Presented at June, 1926, meeting, Western New York Section, A. W. S., also at Annual Convention Master Boiler Makers' Association.

†Consulting Engineer, Union Carbide and Carbon Research Laboratory.

devise special methods to overcome this trouble, as, for instance, the use of bronze for welding malleable iron, and such developments often result in successful welding of materials that are not easily or safely welded by ordinary means.

Again, there is not much use in welding a patch in a badly corrugated side sheet, as the sheet has been injured, and good results cannot be expected. Here, again, however, the question of design enters and a corrugated or dished patch will give better results than a flat one.

Method in welding has been referred to, but it may stand a little further comment. It refers particularly to such things as the allowance for contraction, order in which the weld is made, preparation of the parts, and in general, the procedure followed from the time the job is assigned till it is finished. It is obvious that success can be had only by seeing that the various items involved in this procedure are correct.

The supervision of the work is of great importance. In a large railroad shop the jobs are often widely scattered, and it is much more difficult to keep track of them than in the ordinary production shop. Also, the varied nature of the work calls for close control, which means close supervision. There are very few boiler shop foremen that are welders, and it is therefore imperative that the welding supervisor be of the most competent kind, able to do work himself and also able to impart his knowledge to the welders and to see that they carry out his instructions.

Whether the supervisor can himself train the operators, or whether they should be taught in a central place, depends on conditions. On a very large system the central training school would seem best, unless each shop has a teacher who has time enough to train the men properly. In many cases the supervisor can do it if he is of the right type. But in any case the means is of minor importance, the essential thing being to see that the men are properly and thoroughly trained. It must be remembered that a man may be a very good mechanic but a very poor teacher, and, in fact, the combination of both qualities in one individual is very rare.

One of the most important parts of a welder's training is the testing of specimens of his work. This can be done best by pulling welded test pieces in a tensile testing machine, because it gives actual figures, and as the tests can be made at regular intervals, both during the training period and in his actual service, improvement can be easily noticed, and defects, if any, corrected. If a testing machine is not available fair results can be had by clamping the test pieces on an anvil or in a heavy vise and bending them with a sledge. Such a method is far better than none, as it shows up defects and if properly done, gives a rough idea of the strength.

All finished products are tested in some way, the test depending on the nature of the product. Chemical analysis, hardness tests, breaking of a certain number of pieces, cutting samples from a

finished piece, hydrostatic pressure and comparative tests in service are a few of the many means employed. The hydrostatic test is the one usually employed in boiler work, and it should always be used after any part of the boiler is welded. Hammering the welds with an ordinary hammer, but not hard enough to cause distortion, is sometimes of value and any properly made weld will stand this test easily.

Summing up the above items, we have as the matters that must be given careful attention,

Design
Materials
Methods
Supervision
Training
Testing.

If all of these are properly carried out, there can be no question of the results being successful and satisfactory in every way.

Discussion of Autogenously and Electrically Welded Boilers and Containers

A. F. TONNING†

In reading the June issue of the Journal, I came upon the discussion of a paper on "Autogenously and Electrically Welded Boilers and Containers" by E. Hohn, by W. L. Warner of the General Electric Company and Prof. H. L. Whittemore of the Bureau of Standards. Both Mr. Warner and Professor Whittemore seem to be in the dark concerning welding with water gas as fuel. I think I can tell them why Mr. Hohn makes the statement "that the most efficient process of welding today is that of welding by means of water gas." I want to assure Mr. Warner that this situation does prevail in this country, the development of which I may write about at a later date. I just want to inform Mr. Warner and Mr. Whittemore about the efficiency of a Forge Lap Welded seam with Water Gas as fuel.

The metal is heated to the proper temperature, which is much below the melting point, and with its over-lapping edges is hammered or pressed together and when properly done is as strong relatively to its thickness as any part of the material from which it is made, and makes a smooth, homogeneous weld. The seam is just like any other part of the plate, with the same chemical analysis, having the same tensile strength, elastic limit, elongation and ductility.

†Consulting engineer.

Comments on E. Hohn's Paper on "Autogenously and Electrically Welded Boilers and Containers"*

S. W. MILLER†

I agree with Dr. Whittemore very strongly that there is considerable ingenuity shown in the methods of test devised to determine the strength of various types of welded joints, and this to me is one of the important points in the paper. Another important thing is that it is shown clearly that lap joints in a tank should not be used in longitudinal seams except under low fiber stress. The danger of lap riveted longitudinal seams has been known for years and their use is restricted in all codes to conditions where there cannot be any serious fiber stress. Their danger does not lie in the weakness of the weld, but, as shown in the paper clearly, in the very high stresses in the material next to the weld, which would be of the same order in a riveted joint.

In Fig. 32 in the paper the fiber stress at a short distance from the weld is shown as 21,000 lb. per square inch when the pressure is 213 lb. per square inch, while the theoretical stress at this pressure, considering the shell as a true circle, is only 9650 lb. per square inch. This is a matter that should be more fully investigated, but it is evident that with thick plates at high pressures the stresses will be even greater than those recorded.

It is pointed out that straps welded on one side behave similarly to lap welded joints. Some of these strap seams are patented in Germany by the author of the paper.

Reinforcing rings applied to test pieces show a very great increase in strength over the plain bar with a hole in it, an increase of about 40 per cent being noted. Further tests should be made in this direction, especially with rings on both sides of the test piece. Theoretical investigations should also be made because the test piece is not a thoroughly fair comparison with an actual shell, which has a much larger area over which the stress is distributed, while with the test piece the stress is concentrated within its boundaries.

A reference is made to the contour of the heads in a pressure vessel. This is also a matter that requires careful investigation because it has been found that under high test pressures there are heavy stresses in the knuckle.

It is stated that in gas welding the seams are generally only welded on one side because the seam and the adjacent plate suffer if repeatedly heated. It has been many times observed that the welding on the second side refines the grain of the weld and adjacent metal on the first side welded, and therefore does not injure

*Published in June, 1926, Journal of A. W. S.
†Consulting Engineer, Union Carbide & Carbon Research Laboratory.

it but improves it. It is also stated that the seams are thickened on the outside as much as possible, referring, of course, to the single V. This is bad practice because of the eccentric load imposed, the fiber stress on the inside of the shell being much increased where the reinforcement is heavy. The tests at the Bureau of Standards on pressure vessels, which are described in Bulletin No. 5 of the American Welding Society, show distinctly that it is perfectly feasible to gas-weld on both sides of a shell.

It seems quite clear that there is no danger in fusion welding boilers carrying as high as 180 lb. pressure, and there is no good reason why this work should not be done. It undoubtedly will be carried out as soon as its advantages are thoroughly appreciated, and procedure controls will be developed for the work just as they have in other cases. Finally it appears that all of the pressure vessels illustrated have been welded with electrodes having wound covering and that bare wire was not used.

The Design of Dished Heads of Pressure Vessels*

By S. W. Miller[1], Long Island City, N. Y.

For a number of years the Union Carbide Corporation has been having made in commercial shops pressure vessels for some of its subsidiaries, using oxy-acetylene welding for making the joints. These vessels have been carefully designed, the Boiler and Pressure Vessel Codes of the A. S. M. E. being followed in many respects, the important exceptions being that the design fiber stresses in these codes for welded joints were believed to be entirely too low, higher ones being used.

The first large ones were 7 ft. in diameter, of ¾-in. plate in the shell, the heads being 1 in. thick on the closed end and 1⅛ in. on the manhole end. They were designed for 7000 lb. working fiber stress in the shell and 5600 lb. in the manhole head, using the formulas in Section P-197 of the Power Boiler Code, or U-38 of the Pressure Vessel Code, though in both cases a working fiber stress of 10,000 lb. is permitted.[2]

The Power Boiler Code, Section P-197, says that the inside corner radius shall not be less than 1½ in. nor more than 4 in., and that within these limits it shall not be less than 3 per cent of the radius of the dished head.

The Pressure Vessel Code, section U-38, provides that the corner

*Cuts loaned thru courtesy of Mechanical Engineering.

[1] Union Carbide and Carbon Research Laboratories. Mem. A.S.M.E.

[2] It should be understood that the Power Boiler Code uses a factor of safety based on the ultimate strength of the plate used (in this case 5.5), but that the Pressure Vessel Code uses instead a maximum allowable working fibre stress of 10,000 lb. for plate less than 55,000 lb. tensile strength, and of 11,000 lb. for plate of 55,000 lb. tensile strength or over, so that the Pressure Vessel Code is not quite as strict as the Boiler Code, which provides that the minimum tensile strength of steel plate used in boilers shall be 55,000 lb. (Section S-9.)

radius shall not be less than three times the plate thickness up to $t = 1/2$ in. For thicker plates the corner radius shall not be less than 3 per cent of the dish radius, and in no case less than $1\frac{1}{2}$ in.

The former rule has been interpreted by the Boiler Code Committee so that a larger radius than 4 in. is not forbidden.

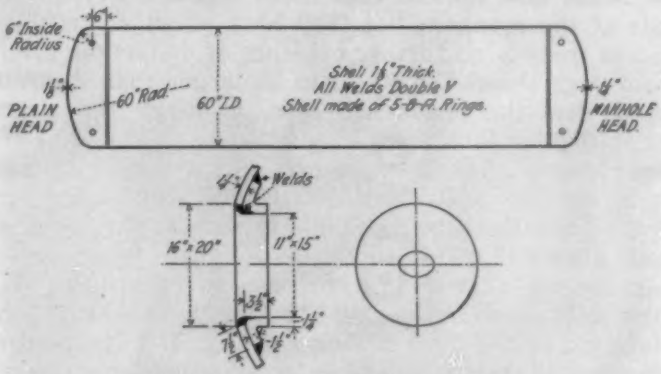

FIG. 1—GENERAL DIMENSIONS OF TANK

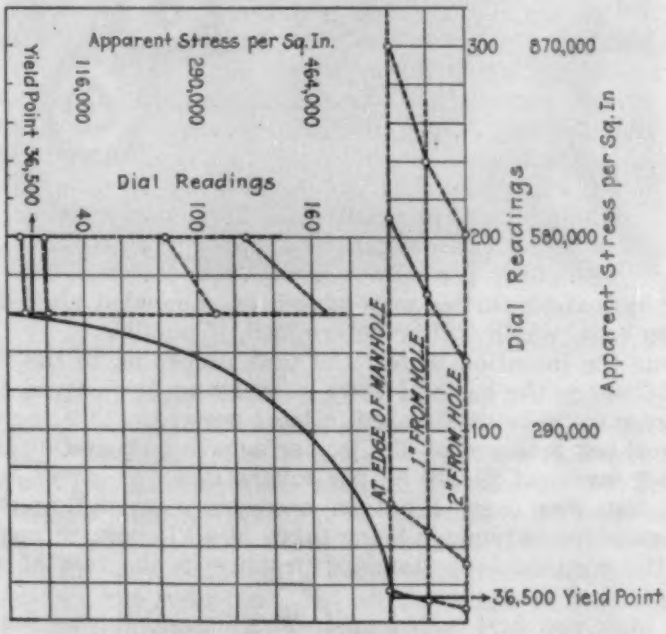

FIG. 2—DEFORMATIONS AROUND MANHOLE OF TANK

The corner radius of these heads was 3 in., and the radius of the dish 84 in., so that the corner radius was within the limits of both codes.

Under test these heads showed heavy stress at the knuckle, but as this seemed to be due to the rounding out of some slightly flat

spots left by the flanging, and as it was not serious at the working pressure, they were put in service. Recent measurements show that the stresses at the knuckle under working pressure are of the order of 11,000 lb. per square inch, so it is considered that this part of the head is safe.

These heads also showed that there was a heavy stress at the long axis of the manhole, but they have given no trouble in service, and as there is no further evidence of distortion, even though the strain gage shows the stress to be larger than desirable, it is considered that the heads are safe, although the stresses are checked at regular intervals.

In designing the latest series of tanks a higher working fiber stress was used, 8000 lb. in the shell and 9000 in the heads, the Pressure Vessel Code being followed except for these stresses. (The code allows 11,000 in the heads.) These tanks were 5 ft. in diameter, for 300 lb. working pressure, and the shell was 1⅛ in. thick, the solid head 1⅛ in., and the manhole head 1¼ in. The general design of the tank is shown in Fig. 1. The corner radius of the heads was increased to 6 in. to avoid undue stresses at that point. The manhole flange contained about 25 per cent more metal than the Pressure Vessel Code calls for.

The manhole head was made of flange steel of the following properties according to the mill test:

Ultimate strength, lb. per sq. in.	57,440
Elastic limit, lb. per sq. in.	36,500
Elongation, per cent in 8 in.	30.25
Carbon, per cent	0.18
Manganese, per cent	0.42
Phosphorus, per cent	0.011
Sulphur, per cent	0.030

Its physical properties may have been somewhat altered by the flanging heat, which will be determined, if possible.

It was the intention to test the tank according to the Pressure Vessel Code on the basis of 9000 lb. working fiber stress, to see if this figure could be safely used in later designs. This corresponds to a working pressure of 337 lb. per square inch and a maximum test fiber stress of 27,000 lb. per square inch.

The test was carried out in accordance with this program, strain-gage measurements being taken at all important points, this being the corporation's standard practice in the case of new designs.

The tank was first tested up to 900 lb., and it was found that the only permanent distortions that occurred were in the heads. On the solid head the only evidence of distortion was the formation of Luders' lines on the knuckle. On the head containing the manhole, however, even at 300 lb., the metal at the inside edge of the manhole stretched beyond the yield point, the apparent stress being about 46,500 lb. per square inch. At 2 in. from the hole it was 23,200, which is still excessive.

Fig. 2 gives the strains in the various places, in divisions on the Ames dial used, each division equaling a stress of 2900 lb. per square inch. The apparent stress figures are also given, though as there was permanent deformation, these figures are of course much greater than the actual stresses. The knuckle of this head also showed Luders' lines.

After 900 lb. had been reached, without any effect except as mentioned, the pressure was released and the strain gage again

FIG. 3—FRONT VIEW OF BROKEN HEAD, SHOWING LOCATION OF STRAIN-GAGE MEASUREMENTS
(Note Luders' lines crossing each other on left side of head.)

applied at all points. No permanent set was found in any of the welds in the shell. There was, however, permanent set around the manhole opening. The pressure was again raised to 900 lb., another set of readings taken, and the pressure further increased after these readings to 1015 lb., in accordance with the schedule, readings also being taken at this pressure. On this second test no further increase of Luders' lines or other evidence of distortion was found on the solid head, but on the manhole head there was further permanent set. The pressure was then released, another set of readings taken, and it was decided to make another test to see if the limit of yielding in the manhole head had been reached, as those making the test questioned the safety of the tank, and it was decided by them to carry the test to destruction unless it showed no further evidence of permanent set on the third test. At 930 lb. per square inch the head broke diagonally through the manhole as shown in Fig. 3.

It is well to have it understood clearly that there was no permanent set or excessive stress at or near any of the welds. The manhole head showed continually increasing distortion as the pressure increased at both the manhole opening and the knuckle. The solid head, though ⅛ in. thinner than the manhole head, showed no sign of distress except at the knuckle, and that only on the first test.

FIG. 4—SIDE VIEW OF FRACTURED HEAD, SHOWING FAILURE IN METAL 6 IN. FROM WELD

It was noticeable after the break that the welds, manhole flange, and head had acted together, as there was no separation of the welds from the manhole or plate.

Several photographs of the tank are given showing the break (Figs. 3-5).

It should be mentioned that the data are not completely worked up yet, and that there may be necessary some minor change in the figures given, but they are close enough for the purpose for which this article is written, which is to point out the need of careful and complete study of stresses around openings in all pressure vessels.

The author suggests that boiler and tank manufacturers (and insurance companies covering these installations) take strain-gage readings on their products when completed, and at such other times after they have been put in service as may be possible, and the following procedure is suggested.

Drill the gage holes in the shop, and take readings at working pressure and the test pressure while under test. At times of

annual inspection have readings taken by those in charge of the vessels or by the insurance inspectors.

The schedule of the tank tests to be made jointly by the American Welding Society and the A. S. M. E. should include tanks made

FIG. 5—FRACTURE THROUGH SADDLE PLATE AND HEAD
(Note that there is no separation between welds and plates.)

with various designs and locations of manholes, and these should be examined with special care.

In all these cases the stresses at the knuckles of the heads should also be measured wherever and whenever possible, as the formulas for these radii are apparently equally as arbitrary and incorrect as are those for manholes.

It is hoped that a more complete report will be given later, including all the data of the test and of the examination of the failed head.

The Arc-Welding Load

BY W. L. WARNER†

In general, the conception of arc welding as a load is formed in terms of the current and voltage at the arc which is causing the welding to take place. These range from 100 to 800 amp. and from 20 to 40 volts, and are supplied to the arc from some direct-current source that is usually a special welding motor-

†Industrial Engineering Department General Electric Company.

generator set. The generator of this set may be of either the single-operator or multiple-operator type.

The overall energy efficiency of the single-operator machine is somewhat higher than that of the multiple-operator machine because of the series resistors used in the welding circuits of the latter for current and voltage regulation, and for this reason one might suppose that the purchaser of welding equipment would generally prefer single-operator sets; but such is not the case. The considerations of first cost, upkeep, and power-factor are often deciding features. Also, the manner in which the welding is to be done has a distinct influence in the selection of the type of equipment to supply the welding energy. Where all the welding is done by hand and the operators are working at widely separated locations, perhaps not in the same building, single-operator machines are chosen. On the other hand, where several welders are working together, or automatic machines are employed, a multiple-operator set would probably be used.

It is impracticable to utilize synchronous motors to drive single-operator generators because the horse power required is comparatively small and the variable-voltage characteristics of the generator would necessitate a separate exciter for the motor. Hence induction motors are employed and as a result the power-factor of the individual sets when running light may be as slow as 25 per cent (lagging). This is ordinarily of little consequence so long as only a few (10 to 15) such sets are installed and the power-factor of the remaining load on the feeder is acceptably high. However, in case there is a considerable number of other induction-motor drives connected to the same service feeder, or the number of single-operator sets is large or may become so (30 or 40 in some shops), the matter of power-factor is of real concern.

Under such conditions, the advantages of improved power-factor can be obtained by installing a comparatively few large induction-motor-driven or synchronous-motor-driven multiple-operator sets. These induction-motor sets when running light may have a power-factor of 25 to 30 per cent (lagging), while with synchronous-motor sets the running light power-factor will be about 80 or 85 per cent (leading). Another advantage of synchronous-motor drive is that the machine can be readily designed to operate at a still higher power-factor.

Obviously the load-factor will tend to have a more beneficial effect on the power-factor of the welding load when multiple-operator sets are used than when a larger number of single-operator sets of equivalent total output are in operation.

Welding loads are inherently of a fluctuating character. At best the load imposed by one welding arc is suddenly applied and as suddenly removed. However, the maximum variation is ordinarily so small compared to the total load on a feeder that its effect is negligible. In case a number of welders are at work either

with single- or multiple-operator machines, the diversity-factor can be depended upon to spread the peaks into a comparatively uniform load.

The rapid development and increasing use of automatic welding machines has brought about a greater demand for large sets of the multiple-operator type which may be driven either by induction motors or synchronous motors.

While the welding load in general has been of minor amount compared to other industrial loads it is fast growing in magnitude as shown by the following figures:

Estimated kilowatt-hours of welding and cutting load:

Year 1923..... 270 millions
Year 1925..... 350 millions

This load is equivalent to about 6 per cent of the electrified load of the iron and steel industry.

First All-Arc Welded Water Pipe Line

W. L. WARNER†

What is said to be the first completely arc welded pipe line in this country and the longest pipe line of its type, was recently completed for the city of Vallejo, Cal. This pipe line has a length of 22 miles and was built for the transmission of water from a new reservoir in the Gordon Valley to the City's Fleming Hill Reservoir, just north of Vallejo.

The City of Vallejo is situated in Solano County, California, near the head of San Pablo Bay, on the east shore of Mare Island Strait. It has a population of 26,000. The water supply is municipally owned and is secured from storage reservoirs in Wild Horse Valley, about 14 miles northeast of the city.

The growth of the city as well as the increasing demand of the Mare Island Navy Yard (supplied by the municipal system) made it necessary to increase the water supply materially. As a result it was decided to develop the Gordon Valley project, involving the creation of a storage reservoir in Gordon Valley at a point about 26 miles northeast of the city, and the installation of a pipe line to the city to connect with the existing municipal distributing system, a total distance of approximately 22 miles.

The pipe line is of steel plate construction, all seams being electric-arc welded. The pipe is 22 and 24 in. in diameter, 15 miles being 24-in. and 7 miles 22-in. pipe. Of the 24-in. pipe there are approximately 11 miles having a wall thickness of 3/16 in. and 4 miles of ¼-in. material, whereas the 22-in. diameter pipe has a wall thickness of 3/16 in.

The complete pipe line was built by the Western Pipe & Steel Company. All steel plates for the pipe were rolled into shape and

†Industrial Engineering Department, General Electric Company

the side seams welded by automatic arc welders. The three machines used are shown in Fig. 1 welding the side seams of the 14-ft. sections of pipe.

After the side seams had been welded, two 14-ft. sections were arc welded together, making a 28-ft. section. These circular welds were made with semi-automatic arc welding equipment. Every section of pipe was tested in a hydraulic testing machine to one and one-half times the designed working pressure, two sections being tested simultaneously. The total static head on the pipe varies from 100 to 400 ft. (44 lb. to 175 lb.) and all of the pipe was tested in the shop to 225 lb. pressure. A number of sections

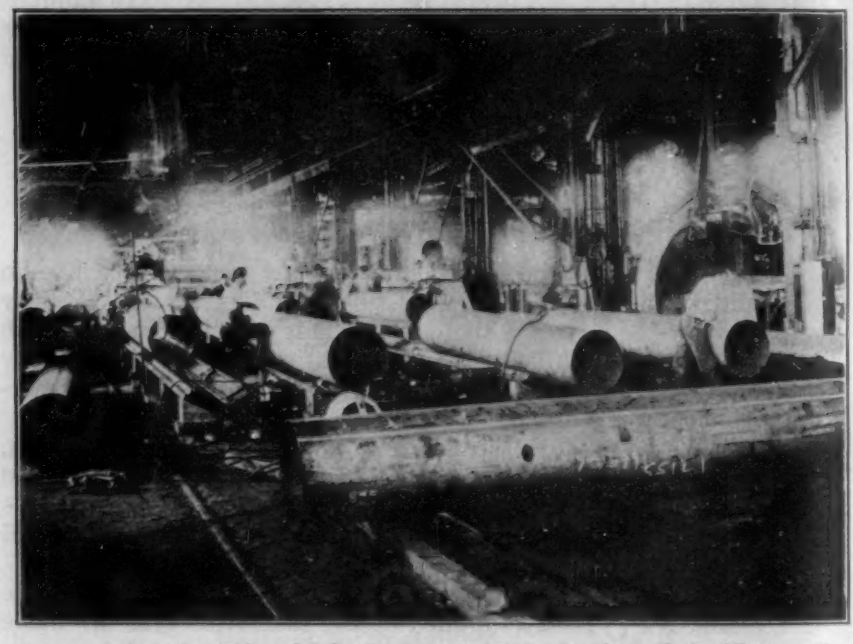

Fig. 1. Automatic welders fabricating water pipe in the plant of the Western Pipe & Steel Co.

were tested to 325 lb. and a few to 720 lb. pressure, but no leaks developed in the welded seams. Fig. 2 shows welded pipe sections in shop prior to testing.

From the testing machine the pipe sections were sent to the dip shed where the soil-proof wrapping was applied. The pipe was dipped in hot asphalt and then wrapped, while hot, with a mica pipe covering consisting of felt which first was thoroughly saturated with a high melting point bituminous compound containing not less than 25 per cent by weight of alkali-resisting mineral and weighing not less than 3.6 lb. per square yard. This felt was put under a tension of not less than 50 lb. per 18 in. of width of wrapping, hot "dip" being run in between the pipe and the felt during the wrapping process.

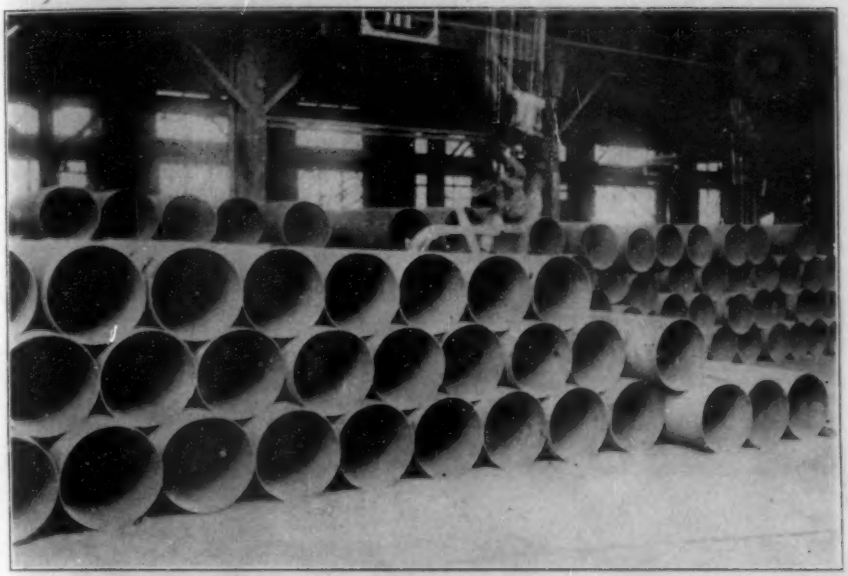

Fig. 2. Sections of welded pipe ready for testing

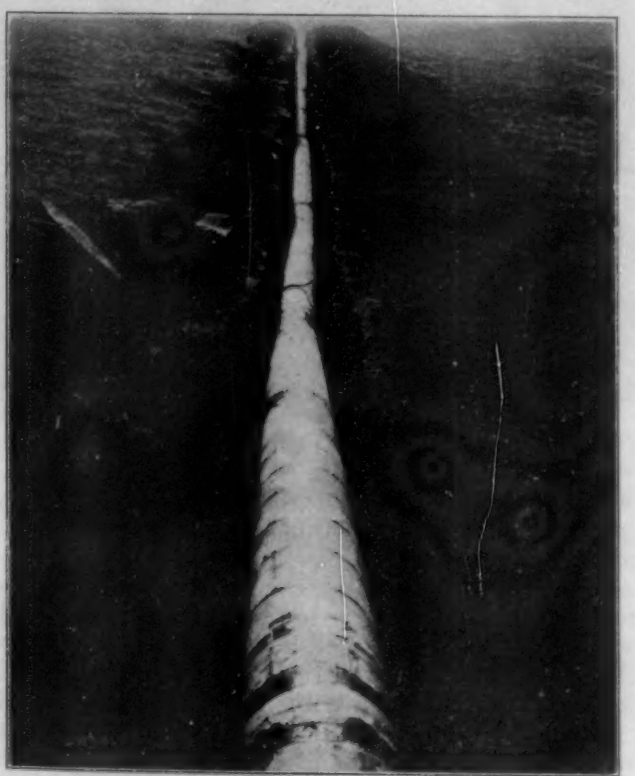

Fig. 3. Section of water pipe completed and ready for test

In many places the grade at which the line was laid was quite steep, in fact, so much so that walking up hill along the line of the trench was no easy task. This is shown by Fig. 4. However, the line was installed with efficiency and dispatch. An idea of the depth of the ditch in some places may be gained from Fig. 3.

The wrapped pipe was transported from the factory to the nearest point to the site of installation by rail and from the siding

Fig. 4. View of pipe line from within ditch

by automobile trucks to the ditch. Extreme care was exercised in loading, unloading and transporting the pipe to prevent damage to the wrapping.

Four sections were welded together on top of the ground after which these 112-ft. sections were lowered into the ditch. This procedure reduced the number of bell-hole joints to a minimum. Fig. 5 shows the method of lowering the 112-ft. sections into the ditch.

During the time of filling the line, but one leak occurred in the straight seam in the entire length. Nineteen girth seams showed leakage or sweats out of a total of 8200 girth seams in the entire length. Of this total, 4100 were field joints, hand welded, and the

remaining seams were shop welded with semi-automatic welding equipment. The field welding equipment used consisted of several gas engine driven welding sets. The leaks were promptly rewelded and stood the final test without difficulty. It is worthy of note that this pipe line was laid in the summer of 1925, during the hottest months of the year and was filled during the winter months.

Fig. 5. Lowering a 112 ft. section of welded pipe into the ditch

The finished 22 miles of pipe was put under final test for forty-eight consecutive hours on March 4 of this year in accordance with contract specifications. During this length of time the pipe was held under a pressure of 200 lb. per square inch at the lowest point in the line and was found to be absolutely free from leaks. During the 48 hours of test the line was continuously patrolled and inspected at all points but no leakage was discovered.

Following the final tests and inspection, the pipe line was officially accepted by the City of Vallejo on April 2, 1926.

This installation is unique in that it is the first all-arc welded pipe of its type ever installed. The actual cost to the City of Vallejo of the pipe line was about 10 per cent less than an equivalent riveted pipe. On a job of this kind this percentage represents a considerable saving.

Electric Arc Welding in the Manufacture of Structural Steel*

A. G. BISSELL†

The fabrication of structural steel work by electric arc welding at present is of greater interest to the manufacturer who is using this material in his work than to the builders of large buildings and bridges. However, in the construction of small buildings and bridges where most of the work is assembled in the field, arc welding is of great value. In this class of work and in fabricating structural steel racks, frames, trucks, etc., arc welding permits of decided saving in material and labor.

During and since the late war many have seen the advantages of joining structural material by arc welding, and up to date there have been numerous applications of this nature. One interesting application of arc welding in the erection of a structural steel building was made at Eola, Ill., where the Chicago, Burlington & Quincy Railroad Company erected a 60-ft. x 40-ft. one-story mill-type building, using scrap steel such as shown in Fig. 1. It is interesting to note that this railroad company erected two buildings of the same size—one riveted and one arc welded. Data furnished by W. T. Krausch, Engineer of Buildings of the railroad company, shows the following comparison in erection costs:

	Arc Welded	Riveted
Preparation Cost including material and shop fabrication	$381.71	$1,000.50
Field Erection Cost	404.49	339.00
Grand Total	$786.20	$1,339.50

From the above figures it will be seen that the saving in favor of the arc welded building lies in the preparation. The only preparation required for arc welding is to produce the steel and cut it to the required length. No clip angles, gusset plates or butt straps are required. Preparation necessary for the riveted job involves shop details and layout, punching, painting, reaming and shop fabrication. The reason that the field erection cost of the riveted structure is less than the welded structure is because all the welded joints were made in the field while much of the fabrication of the riveted structure was done in the shop. Twenty-seven thousand one hundred pounds of steel were used in the riveted structure, while 25,619 lb. were used in the welded structure, a reduction of about 5½ per cent in the amount of steel used in favor of welded building. The saving in steel and the reduction in the total erection cost in this case resulted in a saving of 41.3 per cent in the final cost of the arc welded building.

†General Engineering Department, Westinghouse Electric and Manufacturing Company.

*Presented at Cleveland, Chicago, Buffalo, Boston, San Francisco and Los Angeles Sections of the A.W.S. during 1926.

Even though there have been many applications of electric arc welding in the fabrication of structural steel, the test data involving welded joints has not been complete. Tests have been made on the metal deposited by the arc, but the most logical tests to prove the value of this method of fabricating structural steel, it

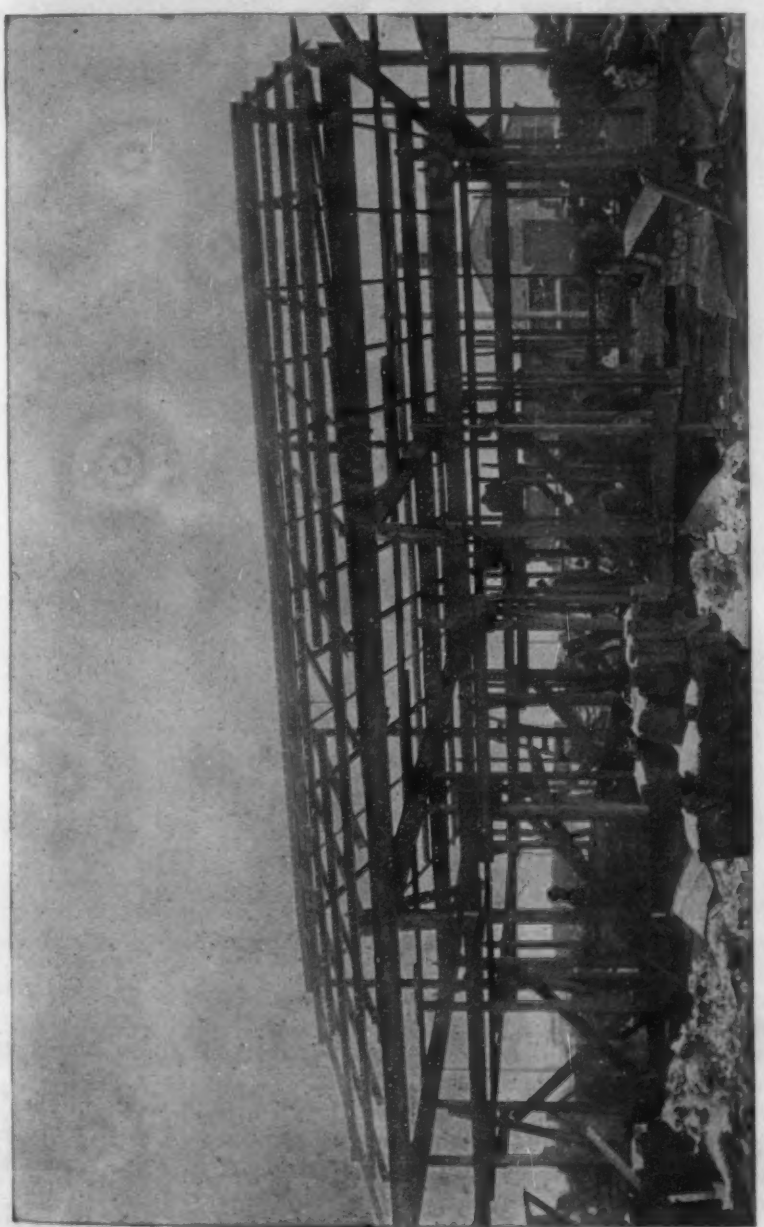

Fig. 1. C. B. & Q. R. R. arc welded building

is thought, should be made on joints made by this process. With this idea in view, some tests were made on actual welded joints under varying loading conditions and stresses.

In determining the tensile strength of a welded joint, the following procedure was followed:

A butt joint was made between two pieces of ½-in. plate and two ⅜-in. plates, beveled 60 deg. The metal was deposited in two

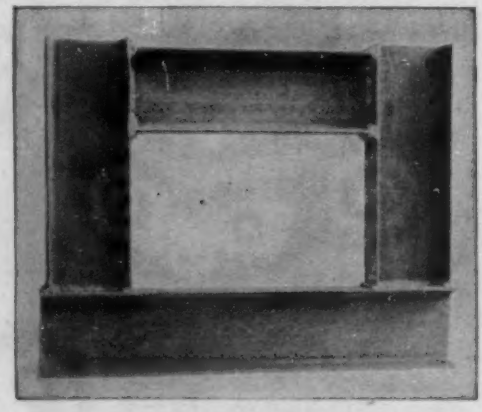

Fig. 2. Test piece for static test before loading

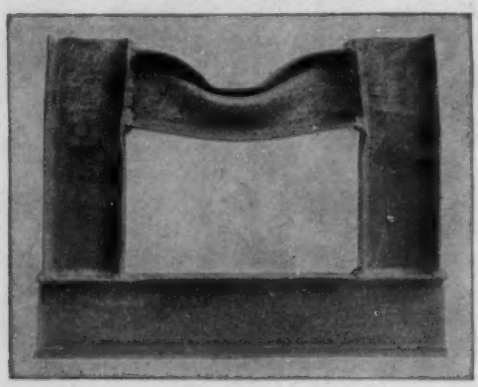

Fig. 3. Piece for static test after loading

layers, using 160 to 175 amperes current and 5/32-in. electrodes. There was no backing behind the seam and the plates were held rigidly in position. Test pieces were cut from these plates and tested for their tensile strength.

The results of these tests showed that the joint made in the ½-in. plate developed an average tensile strength of 64,400 lb. per square inch with an elongation of 4 per cent in 1 in. across the weld. The ⅜-in. test pieces developed an average of 57,100 lb. per square inch with an elongation of 8 per cent in 1 in. across

the weld. Failure in both cases occurred in both base and deposited metal. The steel in which the joint was made had a tensile strength of between 65,000 and 70,000 lb. per square inch. The welding wire was a hard-drawn, mild steel of about 0.17 per cent carbon and 0.55 per cent manganese.

To determine the shear value of an arc welded joint, a test piece was made up. Pressure was applied to the horizontal member in

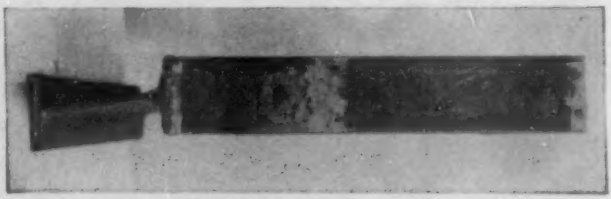

Fig. 4. End view of test piece in Figs. 2 and 3 after loading

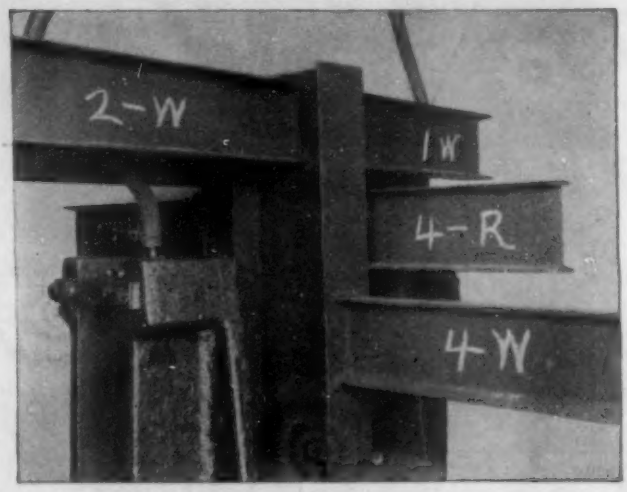

Fig. 5. Vibration test piece showing arc welded connections

a testing machine through a heavy bar that extended within ½ in. of the welded joint. The weld was deposited in 2-in. x ⅜-in. beads which developed a shear strength of 50,550 lb. per square inch.

A test piece to show the resistance of arc welded joints to a static load was made by uniting four 6-in. x 12.25 lb. I beams as shown in Fig. 2. In this test piece the 18-in. horizontal cross-member was attached to the flanges of the vertical members by fillet welds around the contacting parts as shown in the photograph. To test this structure it was placed in a hydraulic press and pressure applied to the center of the horizontal member through the end of a piece of 3-in. shafting.

At a pressure of 40 tons the horizontal and vertical members

began to deform, the pressure falling to 35 tons. This pressure was applied until the horizontal member was deformed, as shown in Fig. 3. The extent of the crushing was limited by the base "I," which deformed as shown in Fig. 4, causing the test piece to slip

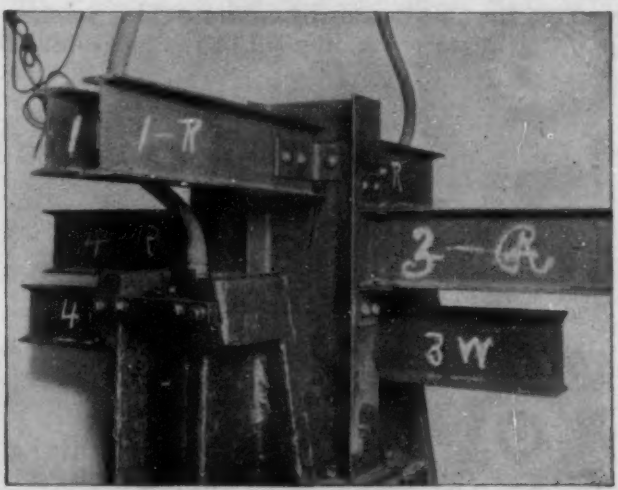

Fig. 6. Vibration test piece showing riveted connections

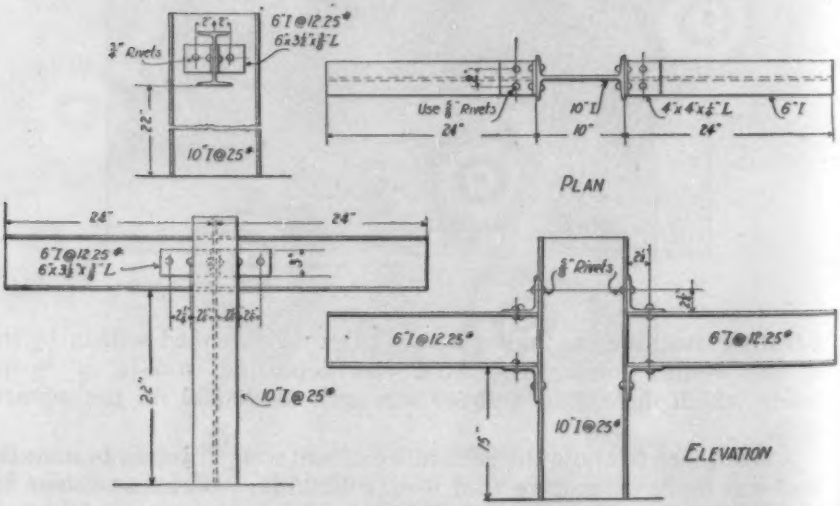

Fig. 7. Drawings of vibration test piece showing details of riveted connections

out of the press. An examination of all the joints in this test piece after the test, failed to show any evidence of failure in the welded joints, proving that a joint of this nature will hold even though the connected members may be badly deformed.

To determine the effect of vibration on arc welded joints in struc-

tural steel, a test piece was constructed of two 10-in. x 25-lb. beams to one of which were arc welded four 6-in. x 12.25-lb. I beams 24 in. long. To the other was riveted four 6-in. x 12.25-lb. I beams 24 in. long.

As can be seen in Fig. 5, the 6-in. I's are attached to the web and flanges of the 10-in. beam by a fillet weld. The only preparation required in making these joints was to clean the scale from the parts to be welded. These welds were made by an average welder working under the same conditions that might be expected in

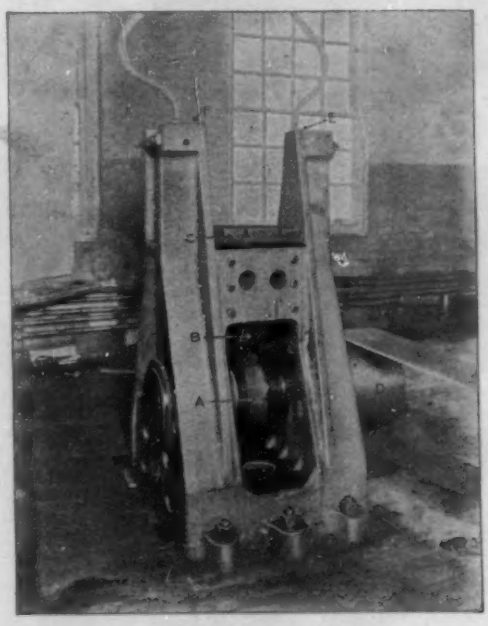

Fig. 8. Vibratory test machine

actual practice. Each joint required approximately 0.6 lb. of metal and from 12 to 15 minutes to weld, using 5/32-in. wire at 150-160 amperes. This makes the cost of this joint around 35c. for the welding if the operator receives $1 per hour.

A riveted joint uniting the members in a similar manner is shown in Fig. 6. Two 6-in. x 12.25-lb. I beams 24 in. long were riveted to the web of the 10-in. x 25-lb. I. A standard beam connection was used as specified on page 246 of the Carnegie Steel Company Pocket Companion, Twentieth Edition, 1919. This shows that beam connections for 7-in., 6-in. and 5-in. I beams are made using 2 L's. 6 in. x 4 in. x 3 by 8 in. x 0 ft. -3 in., with two ¾-in. rivets through the 4-in. leg of each clip holding it to the web of the other member. In this test piece, in order that the 6-in. I might be attached to the web of a 10-in. I, it was necessary to use 6-in. x 3½-in. x ⅜-in. angle clips and space the two ¾-in. rivets

4½ in. instead of 5½ in. Otherwise the joint was standard. This joint is shown in detail by drawing A in Fig. 2.

In order to have a 6-in. I beam attached to the flange of the 10-in. beam by riveting, a joint as shown in B of Fig. 7 was calculated. Two 4-in. x 4-in. x ¼ x 0 ft. -3 L-pieces were riveted to

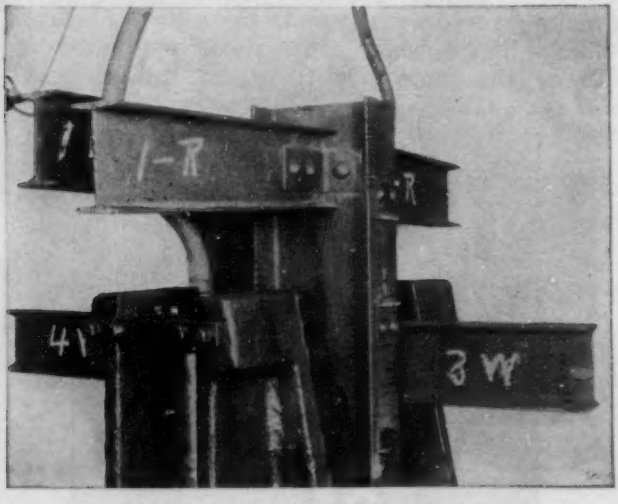

Fig. 9. Riveted vibration test piece after first test

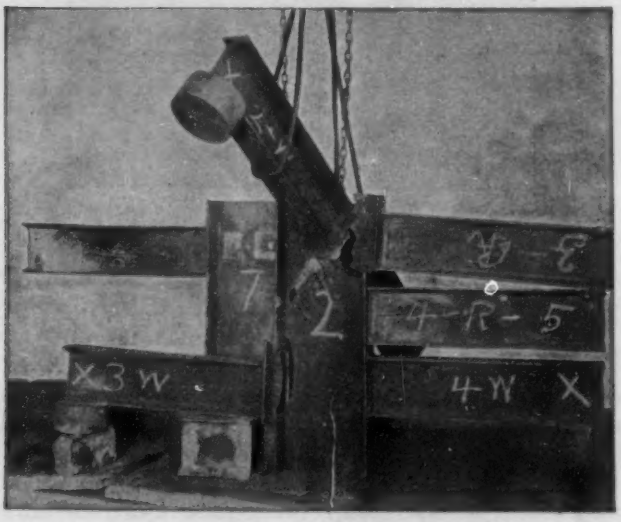

Fig. 10. Test piece after second test

the flanges of the two members by ⅝-in. rivets, two through each leg of the clip angles. In both of these riveted test pieces the rivets were driven hot by hand.

Both riveted and welded test pieces were mounted on a 1-in.

plate 14 in. x 22 in. by uniting the 10-in. I beam and this plate with a fillet weld. This combined test piece was securely bolted by 4-in. bolts to the bed plate of a vibratory test machine and subjected to a vibration, or vertical movement, of 1/16 in. at the rate of 1760 complete cycles per minute.

This vibratory testing machine is shown in Fig. 8. It consists of a pulley (A) having eight flat surfaces equally spaced around the external face, mounted in extra heavy bearings and driven at 220 r.p.m. by a motor through pulley (D). Just above (a) is a smooth faced pulley (b) held by heavy bearings to the bed plate (C). This pulley and bedplate are free to move in a vertical

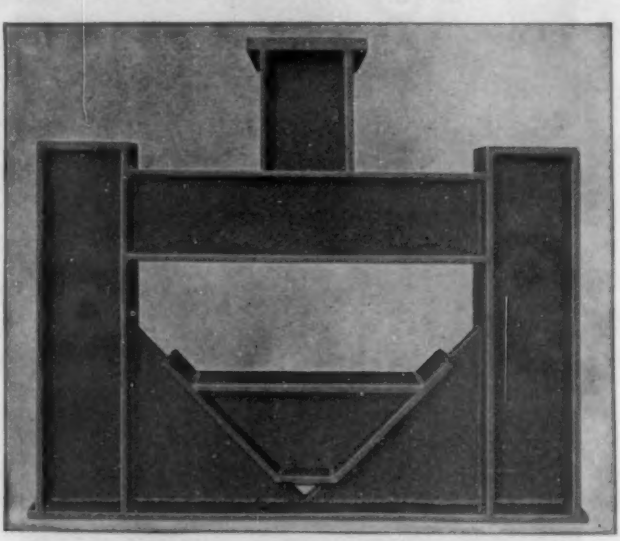

Fig. 11. Shock test piece before testing

plane. As pulley (A) is rotated, its flat faces cause pulley (B), and therefore the bedplate (C), to rise and fall 1/16 in. To make this bed plate return immediately after rising an air pressure piston is installed at each side (F & E) which keep a constant down pressure on the bed plate and insure contact between pulleys A and B. Pulley D is operated at a speed of 220 r.p.m, which gives the bedplate 1760 vibrations per minute.

In order to identify the members of these test pieces, they were marked as follows:

1R and 2R—Riveted to opposite sides of web on the 10-in. I beam.

3R and 4R—Riveted to the flanges of the 10-in. I beam.

1W and 2W—Arc welded to the opposite sides of the web of 10-in. I beam.

3W and 4W—Arc welded to the flanges of the 10-in. I beam.

The first test period lasted 18 hours and 20 minutes. At 24 minutes of vibration the lower clip angle on specimen 3R failed.

At 42 minutes the lower clip angle in 4R failed. At one hour the upper clip angle on 3R failed, removing the member. 4R was removed when the remaining clip angle failed at two hours and four minutes. The nature of the failures can be seen in Fig. 9. It will be seen that the failure was due to the fatigue of the metal in the clip angles.

Within an hour after the vibration was started the clip angles on 1R and 2R began to show a movement that increased until at

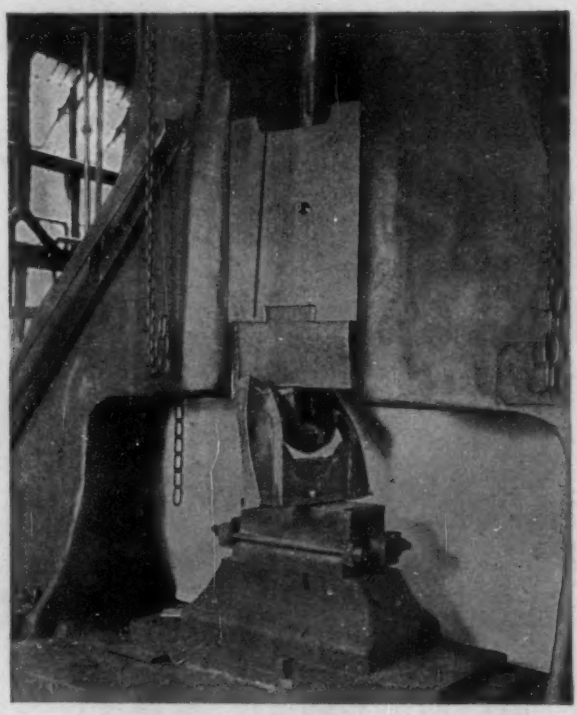

Fig. 12. Shock test piece and 2000 ton hammer

3 hours and 45 minutes the rivets had been loosened sufficiently to allow a movement of ¼ in. at the free end of both 1R and 2R. By 4 hours and 15 minutes this movement had increased to ½ in. By this time the vibration was exerting very little effect as these members were so loose that they received but few of the shocks —simply bouncing up on about every fifth or sixth vibration. The result of this movement was to swage the rivet down to a reduced cross section and enlarge the rivet holes.

During this time the arc welded test piece attached to the same base was receiving the same vibrations. At all times during the 18 hours and 20 minutes of vibration the arc welded members gave a clear ring when struck with a hammer, showing that no failures had started in or about the welds in the first period of the test. It might be mentioned here that all four of the holding-down bolts through the base of the test piece failed

from fatigue, illustrating to some extent the severity of the test.

As it appeared that it would require considerable time to produce a failure in any of the arc welded members it was decided to attach a load to the end of each member and thus accelerate the test. 25-pound sections of 6-in. shafting were arc welded to members, and vibration continued for 22 hours and 10 minutes.

At the end of an hour on the second period the web surrounding the section to which members 1W and 2W were attached, failed. It will be noticed in Fig. 14 that these members are still securely attached to each other through a section of the web. After 20 hours and 40 minutes on the second period and a total

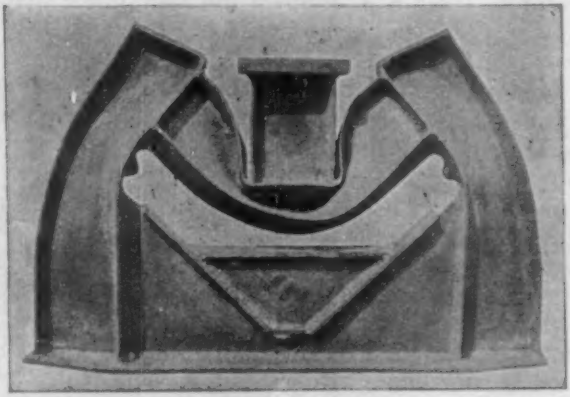

Fig. 13. Shock test piece after testing

of 39 hours and 5 minutes, the flange and web of the 10-in. I beam to which 3W was attached, gave way as shown in Fig. 10. This failure was probably due to the web of the 10-in. I cracking down from the top. Had this crack not occurred, 3W would probably have held indefinitely, because at the end of this period 4W was intact and there was no evidence of failure in the weld or in the surrounding metal. After 3W was removed the vibration was continued for an additional hour, but owing to the damaged condition of the 10-in. I beams both being badly cracked, the test was discontinued.

After having found that the arc welded joints in structural steel were capable of withstanding as much static and vibratory loading as the structural members themselves, the only remaining test data to be obtained was the effect of shock in these joints. The test piece to be subjected to a sudden shock in Fig. 11 was made by arc welding two 6 in. x 12.25 lb. I beams 24 in. long to a ½ in. x 3 in. base-plate. These vertical beams were joined near the tops by a similar beam of the same length. This was attached to the flanges of the vertical beams by a fillet weld having approximately ⅜ in. contact on each member. To receive the blow an 8 in. piece of a 6 in. I beam, capped with a piece of 1 in. plate, was attached to the center of the upper flange of the horizontal

member. To prevent the vertical members from collapsing and the base from buckling, the bracing shown in Fig. 11 was installed. Since the horizontal member was attached quite near the tops of the vertical members, caps were welded to the top ends of the vertical beams to prevent them from splitting through the web.

This test piece was placed on a solid foundation consisting of a heavy plate supported by the anvil and two 12-in. x 12-in. timbers under a 2000-ton steam hammer shown in Fig. 12. First a light blow was delivered upon the plate on the extended I to settle the set-up. The effect of this blow was not evident, so a blow of approximately one-third the capacity of the hammer, or about 700 tons, was delivered on the 1-in. plate that capped the extended beam. The impact of this blow drove this short piece into the horizontal member, which, in collapsing, drew in the vertical I beams bending them at the top of the cross braces as shown in Fig. 13. There is no doubt that a very severe shock strain was transmitted through the welded joint that connected the vertical and horizontal members, more severe, in fact, than any structure would be expected to stand in practice, and yet the welded joints did not fail.

In summarizing the data obtained, the following points indicate the stability of arc welded joints. The deposited metal in an arc welded joint develops an average of 60,000 lb. per sq. in. tensile strength, and 50,550 lb. per sq. in. in sheering strength. Such joints proved strong enough to remain intact while the structural steel members were badly deformed under a static load of 40 tons. When subjected to vibration of 1760 reversals per minute, arc welded joints surpassed standard riveted joints in permanence, and showed a longer life than the structural material joined by it.

Under a sudden shock produced by a blow of approximately 700 tons, the arc welds in a test piece did not fail, even though the structural steel members were severely strained and deformed.

From the results of the foregoing tests it is concluded that arc welded joints in structural steel are capable of withstanding any stresses that the structural members will withstand without deformation and will remain intact even after the structural members are deformed or broken. Under both a steady pressure and under shock, the welded joints are capable of remaining intact, even though the structural steel members that they unite are badly deformed. Under vibration, contrary to the expectation of many, arc welded joints do not fail, nor do failures in the beams appear to be due to rearranged structure in the surrounding steel resulting from the welding.

In regard to the cost of making arc welded joints, it may be said that a $\frac{3}{8}$-in. fillet weld as used in the described tests can be put in for from 15 cents to 20 cents per linear foot of bead, depending upon the position of the work. This is based upon labor at $1 per hour, wire at 10 cents per pound and electrical energy at 0.02 cents per kilowatt-hour.

Discussion of "Some Unsolved Fundamental Gas Welding Problems"*

P. HOLLARD†

It is always interesting to follow regularly, studies and work done in foreign countries in connection with questions that interest us directly, to record the individual trials, the collective tendencies, and the results obtained by the technicians of other countries, so we read with attention what has been written by a prominent member of the American Welding Society, Mr. S. W. Miller in the May number of the Journal of that Association, on "Some Fundamental and Unsolved Problems in Connection with Oxy-Acetylene Welding."

The expression "neutral flame," more used in English than in our language, means a flame that is neither oxidizing nor carbonizing, therefore without chemical action on the metals which are submitted to it. The tests made here up to the present time have been logically of a chemical order. A torch normally adjusted was presented to a piece of metal, which, after having been heated to a distance determined by the size of the nozzle, was examined with regard to chemical alterations it had undergone. Such was the type of our test. It remained to determine what it was necessary to understand by normal regulation.

Can the spectroscope study of the flame give indications more interesting and even equal? It is possible, but they will be theoretical indications, while we desired above all, to fix our attention on the effect produced by the flame on the metals tested. The study of the effect seems to us then more indicative in the case of oxy-acetylene welding.

But even if with the aid of a spectroscope the investigators defined with precision how one can obtain a neutral flame in the laboratory and why this flame is truly neutral will the welder be further advanced by this? It would be said to him, for example, that his torch should use 1.006 of oxygen for one of acetylene. With the greatest will in the world will he be able, under given conditions, to regulate his flame better? Unless by being able to put at his disposal a torch giving automatically the said neutral flame under all the conditions of work, pressure, purity of gas, heating, etc., the manufacturers of torches cannot do better than to provide an easy regulation of the flame. We come back, then, to the regulation by the operator, who it is necessary to say, takes instinctively for his basis the effect produced on the metal and not only the appearance of the welding flame.

Certainly, physical and other researches are always interesting and we guard ourselves well in criticising a priori those proposed

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by Mr. Miller. We do not doubt that with the important resources at the disposal of American laboratories an interesting set of results should be furnished by these means, but we will think the question of the effect produced on metals by the oxy-acetylene flame is for us of a more direct interest.

Let us recall in a few words what is known on this subject according to the tests made at the Central Office and possibly others.

If one takes an actual torch of a current model regulated as is done by 99 welders out of 100, and, using the hottest part of the flame, just outside the end of the wide cone, heats with it a metallic oxide, oxide of copper for instance, this oxide is transformed into pure metal. There is reduction so that such a flame is reducing in fact, which is of still more value than to be neutral in theory. And it is not with a scientific object nor even by a scruple of conscience, that welders, apart from the incompetent ones, see to it that this regulation is and remains constantly so. It is simply because a flame called normal facilitates the execution of welding.

The second problem (resistance of welds at high temperatures) proposed by Mr. Miller is connected with general metallurgy and we can only approve strongly of research in this direction.

In the third place Mr. Miller proposes non-destructive tests of welds.

All the technicians and users of oxy-acetylene welding will be in accord with Mr. Miller on this question that is always on the program and that has never yet been solved in a satisfactory manner. We can only wish good results to the investigators in all countries that actually work on it.

The fourth problem suggested by Mr. Miller reflects an American tendency that we have already had occasion to quote to our readers. It is the investigation of welding materials of high strength. They are striving in effect in the United States to obtain rigid welds offering a high resistance to tension in plates of less resistance and more ductility, and that by the employment of nickel steels or other such welding rods. In place of seeking, as we do, to have the welds as highly resistant to tension as the unwelded sheet and giving equally good results in bending, Mr. Miller wishes to have welds that are resistant to bending and that are of a higher tensile strength than the sheet; they should not break in the weld under the effects of tension and the bending should take place in the original plate.

Such is the thesis sustained, and it is sustainable. Added metals have been obtained which gave welds of a tensile strength of 67,000 lb. per square inch. Mr. Miller wants more, and asks the interested producer to carry out research on the subject. It would be also well we think, to carry out practical tests in order to compare the value of the principle of welding we have just described with that of the usual method or at least follow atten-

tively the experiences on the bursting of pressure vessels that will be made in America.

Mr. Miller expresses finally the view that a kind of procedure be established for certain number of types of work where oxy-acetylene welding plays an important part. The effect which is to be determined in each case would be the design of the pieces, the materials, the tests to which operators would be submitted, the methods of execution, the examination and test of the finished pieces, the whole being adapted perfectly to the process of gas welding with the view of obtaining the best results, without the users of the process being required to grope around as did their predecessors, but on the contrary profiting from past experience. There would be thus established a kind of specification fixing the minimum conditions of execution of work by oxy-acetylene welding in the interest even of those who do the work.

This, certainly, is a quite vast program. Its author, taking account of the impossibility of producing a specification of general character applicable to all cases, turns naturally to his association of fusion welding and suggests that a special committee be formed which would receive from users, proposed procedures bearing on such and such work, would examine them, and would return them to the said users with corrections and advice. It would only remain then on the industry to fix the particular details which it alone needs. This technical committee would play on the whole, somewhat the role of L'Office Central de L'Acetylene and Soudure Autogene, which has many times been called upon to study for the industry, problems of this type. If the Office Central has not had more often to establish quite as complete plans as those mentioned above, the fault is with the industry, which generally waits before asking counsel till it finds itself in embarrassment following errors that it would not have committed if it had commenced by making an appeal for the assistance of technical specialists.

French industries have then the advantage of having at their disposal an organization that has existed already for a long time, and for that reason much the better supported by evidence, ready to examine their projects and to answer their questions, being able beside to assign experienced delegates to visit the installations and adjust details of fabrication. The wish that the Americans have to see created a committee responsive to the same needs and fulfilling almost the same functions is for us an encouragement to use as much as possible that which we have at our disposal. Users and technical advisers will thus work in the general interest of the industry of oxy-acetylene welding as well as all other industries.

The last problem that Mr. Miller sets up, has the subject for study, "The Best Metals for Oxy-Acetylene Welding."

Here is a very important question which is also on the order of the day with us. To be well studied it will be necessary first,

that those who use oxy-acetylene welding take careful account of the influence of the nature and of the quality of metals for welding on the ease of execution and the value of the welds, as well as of the necessity of exercising careful control on the metals originally designed for welding. In connection with that, the industries interested should use as much as possible the means of control at their disposal, and constantly resort to the most powerful means possessed by special laboratories in the examination of metals. It is equally indispensable to have producers of metals understand the importance of the outlets that they can assure to their products if those are well suited to oxy-acetylene welding. There is in this respect a double campaign that our Revue as well as the organizations whose activities it reflects, have conducted for a long time and will pursue without relaxing in the interest of all. We will confine ourselves to quoting the case of copper, of which coppersmiths abandoned gas welding following the disappointments due to the improper quality of commercial sheet. It is now welded with success since the dangers of the oxide have been shown and since the same coppersmiths find that there are jobbers who carry the deoxidized copper of welding qualities. We can also mention the selection of aluminum by the test of corrosion, the means of protecting impurities in the center of the steel plates, etc. The question has thus been stated, and it is to be foreseen that in the near future the studies made as much in America as in France and elsewhere will permit of assembling and sending out among those interested, information suitable to help and develop the rational application of oxy-acetylene welding. It is then seen that the simple announcement of the several problems proposed by Mr. Miller imply the work of undertaking and pursuing. Their solution will be shown by notable progress in the conditions of application and in the results given by the process. It is interesting to note how much, in spite of certain differences in points of view his ideas approach ours. It is an excellent sign. On both sides of the Atlantic the same objects are pursued for using or in proposing almost the same means. The coincidences should encourage us on both sides, and the differences should make us reflect and exercise toward ourselves a little of the critical spirit that we are disposed to apply to that which others are or think.

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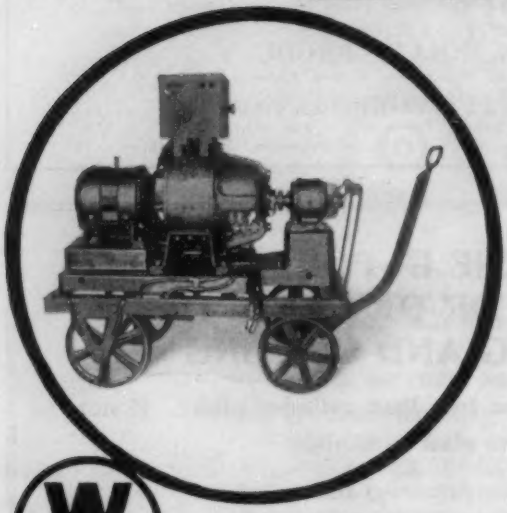

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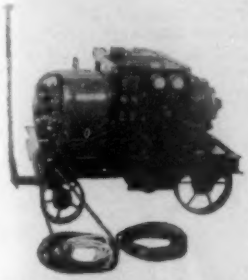

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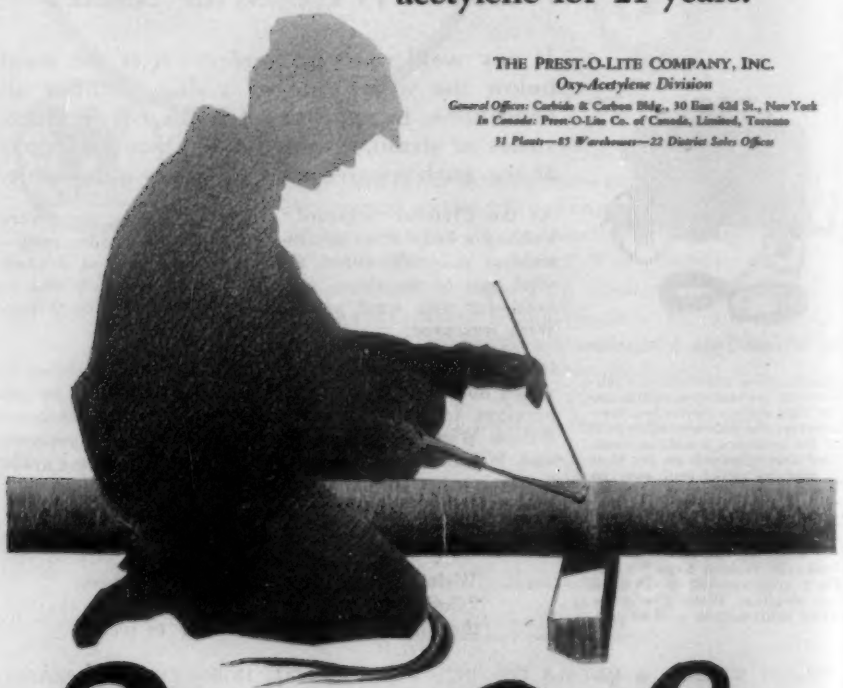

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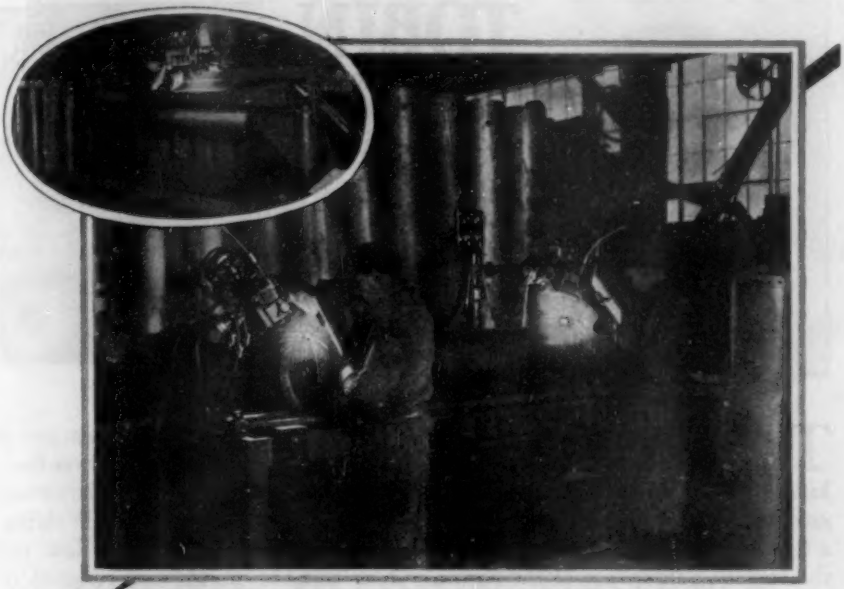

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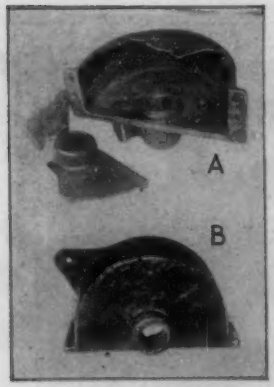

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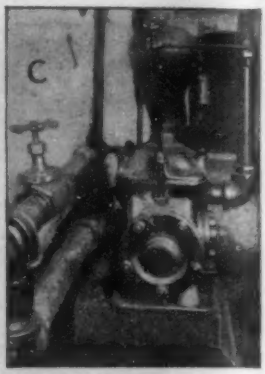

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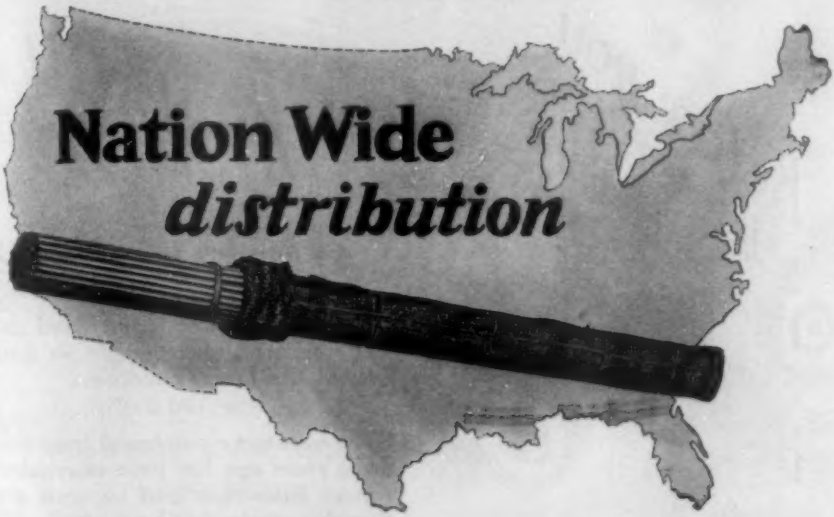

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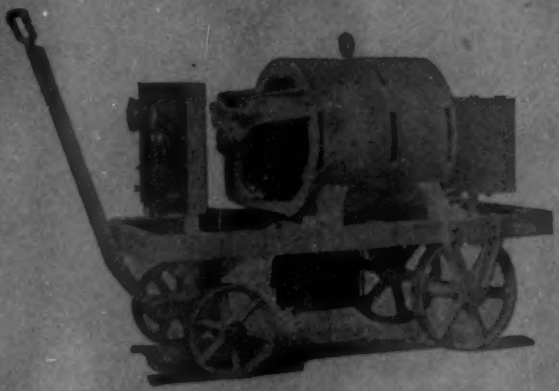

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